

METHOD OF TRANSMITTING LAYERED VIDEO-CODED INFORMATION

Technical Field

Embodiments of the present invention relate to transmitting video information over a network. In particular, embodiments of the present invention relate to methods for setting a transmission priority for layered video-coded information that is to be transmitted over a network.

Background of the Invention

One of the most promising applications in the field of communications is the transmission of encoded or compressed video information across mediums such as telephone networks, cable television networks, and the Internet. The video information is typically encoded at one location, transferred over a network to a destination, and decoded at the destination. A video encoder may be used to, among other things, receive video signals and other data, convert these to digitized form (if the data is not already in digitized form), and compress the data using an encoding algorithm. Examples of video encoding algorithms are the MPEG-1, MPEG-2, and MPEG-4 digital video-coding standards of the Motion Picture Expert Group and the H.261 and H.264 standards from the ITU-T (International

1 Telecommunications Union--Telecommunications sector). The video
2 information may be first obtained from a video camera that generates video
3 signals which contain a series of video frames that each depict images. In
4 addition, the video-coded information may also include other components
5 such as, for example, animations, text, and/or audio information. A video
6 decoder may be used at the destination to decode the received video-coded
7 frames into a format that may be displayed by a video monitor or other
8 device.

9 The networks over which video-coded information is transmitted
10 generally have limited bandwidth. The amount of bandwidth available at any
11 given time depends upon factors such as the amount of traffic and the
12 operability of network components. The amount of available bandwidth is a
13 major parameter for the quality of the video presented by the video decoder,
14 with an increase in bandwidth increasing the quality of the video. The
15 unavailability of bandwidth may cause video-coded frames to be lost or
16 delayed while being sent across the network due to network congestion or
17 buffer overflow. Such losses and delays may cause severe degradation in
18 perceived quality of the video displayed by the video decoder and may result
19 in error propagation, especially where the video is sent in real-time or
20 streamed or where the video contains objects in motion.

21 One way to combat the impact of limited bandwidth is to use a
22 "layered" video-coding scheme. Layered video-coding schemes divide a
23 stream of video-coded frames into layers. In the standard layered video-
24 coding scheme, the video-coded information signal is divided into a base
25 layer and an enhancement layer. The enhancement layer typically provides
26 refinement information that is added to the base layer to provide higher
27 quality. For example, the base layer may typically be decoded and
28 displayed without any data from the enhancement layer, although this would
29 probably result in reduced picture quality. When network congestion occurs,
30 packets may be dropped from the enhancement layer, but valid video at a
31 slightly lower quality may still be produced by decoding packets from the
32 base layer.

1 Traffic that is sent over a network is often classified by a priority level.
2 In many networks, the priority level will be used if the network needs to drop
3 some of the packets being transported. For example, if network congestion
4 occurs and the network has to drop packets, the network will typically drop
5 the lower level packets. A video encoder may take advantage of these
6 classifications by designating some video-coded frames as high priority and
7 the rest as low priority. For example, every fifth frame may be sent as high
8 priority, with the rest being sent as low priority. A typical layered video-
9 coding scheme is to transmit enhancement layer traffic over the network with
10 a lower priority than the base layer. Another scheme, which is referred to as
11 using multiple threads, codes the base layer frames independently, using
12 only previous base layer frames for motion compensation, and codes the
13 enhancement layer frames normally, using both base and enhancement
14 layer frames for motion compensation.

15 A problem may occur when using a layered video-coding scheme if
16 there are simultaneous attempts to transmit high priority base layer frames.
17 If this occurs, the network may become overloaded with high priority data. In
18 this case, either base layer frames may be lost, causing drastic quality
19 reduction, or the network may be forced to buffer some of the base layer
20 frames, causing excessive delays.

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23 **Summary of the Invention**

24 Embodiments of the present invention alleviate degradation in a
25 layered video-coded system by using feedback from the network indicating
26 whether or not capacity is available for sending the high priority frames. The
27 feedback may include a response to a request for information on whether the
28 network currently has the available capacity to transmit additional high
29 priority traffic. In an embodiment, a candidate base layer frame is
30 transmitted over the network as a base layer frame if permission to send
31 high priority data was granted and is transmitted over the network as an
32 enhancement layer frame if permission to send high priority data was

denied. In a further embodiment, a candidate base layer frame is deleted if permission to send high priority data was denied.

Brief Description of the Drawings

FIG. 1 is a block diagram of a system including a video encoder and decoder according to an embodiment of the present invention.

FIG. 2 is a block diagram of a video encoder according to an embodiment of the present invention.

FIGS. 3-7 are flow diagrams of methods of transmitting video information according to embodiments of the present invention.

Detailed Description of the Invention

The present invention provides an improved method of transmitting layered video-coded data by using network feedback which indicates whether bandwidth is available to send high priority frames (e.g., base layer frames). In an embodiment, the encoder does not decide a priori which frames are to be transmitted as base layer frames, but rather requests permission from the network to transmit high priority data before encoding a candidate base layer frame. In this embodiment, the candidate base layer frame may either be encoded and transmitted as a base layer frame if permission to send high priority data is granted or may be transmitted as a low priority frame, or deleted from transmission, if permission to send high priority data was denied. This and other embodiments are described in more detail below. By using an embodiment of the present invention, the likelihood of network overload is minimized because the arrival of high priority data into the network is randomized. In addition, embodiments of the invention avoid buffering large amounts of data and thus avoid the delay that such buffering may cause. Use of the present invention may therefore alleviate degradation of perceived picture quality due to loss of frames or buffering delays.

FIG. 1 is a block diagram of a system including a video encoder and decoder according to an embodiment of the present invention. FIG. 1 shows a video encoder 110 and a video decoder 120 both of which are coupled to a network 130. The term "coupled" is intended to encompass and be broader than the term "directly connected." As discussed below, encoder 110 or another device may transmit video-coded data (such as video-coded frames 113) to decoder 120 across network 130 at a priority level that is determined using information about the network's available capacity (such as network capacity information 116). This information may be provided in response to a request for such information (such as network capacity request 115). Of course, the present invention is not limited to the system shown in FIG. 1. For example, in other embodiments, video-coded data may be sent by an encoder such as encoder 110 to devices other than a decoder. For example, encoder 110 may send video-coded data to a data storage facility for later use by a decoder. As another example, video-coded data may be sent from encoder 111 to a transmission device which transmits the data across the network. Similarly, in other embodiments, stored video-coded data that had been previously encoded may be transmitted to a decoder such as decoder 120 by a device other than an encoder.

Network 130 may be any information systems network across which information can be sent. Examples of network 130 include the Internet, an intranet, a wireline telephone network, a wireless telephone network, a virtual private network, or any combination of these networks. Encoder 110 may be used to encode video data, such as video signals 112, for transmission across a network as video-coded frames. Encoder 110 may output video-coded data that complies with a video-coding standard or algorithm such as MPEG-1, MPEG-2, MPEG-4, H.261, and H.264. In FIG. 1, encoder 110 is shown coupled to a video camera 111. In an embodiment, video camera 111 outputs video signals 112 to encoder 110. In other embodiments, encoder 110 may encode prerecorded video signals or may receive other types of input such as animation, text, or audio data. Decoder 120 may be used to receive and decode video-coded frames for display as

1 video images. Decoder 120 is shown coupled to monitor 121 and may
2 output decoded video data, such as video signals 122, for display as video
3 images on monitor 121.

4 As shown in FIG. 1, network 130 includes a network access server
5 131 that connects encoder 110 to network 130 and a network access server
6 132 that connects decoder 120 to network 130. Network access server 131
7 and network access server 132 may permit connections to network 130 from
8 outside the network and may be operated by a third-party such as AT&T
9 Corp.® or America Online, Inc.® Network 130 includes a network
10 administrator 133 which administers operation of network 130. In an
11 embodiment, network 130 may be decentralized and may contain multiple
12 network administrators. Fig. 1 shows a high priority channel 134 and a low
13 priority channel 136 coupling network access server 131 to network access
14 server 132. In an embodiment, high priority channel 134 and a low priority
15 channel 136 are logical paths across network 130, and data may be
16 transmitted across each logical path using various physical paths. In an
17 embodiment, network 130 contains a plurality of virtual circuits that may be
18 used to transmit high priority traffic and a plurality of virtual circuits that may
19 be used to transmit low priority traffic. In an embodiment, network 130
20 contains a plurality of nodes, such as router or switches, and many of these
21 nodes may be used to transmit data for both high priority channel 134 and
22 low priority channel 136.

23 A person of skill in the art would appreciate that the amount of traffic
24 across network 130 may be dynamic, and thus that the amount of available
25 bandwidth may be constantly changing over time. At any given time,
26 network 130 may experience congestion and may be unable to provide
27 bandwidth for transmitting additional data. When network congestion
28 occurs, network 130 may take appropriate actions such as dropping data or
29 buffering data. For example, if a data packet XYZ is sent from network
30 access server 131 to be forwarded across network 130 to network access
31 server 132, but network 130 does not have the bandwidth to transmit data
32 packet XYZ, then data packet XYZ may be dropped and a message

1 indicating this dropping may be transmitted back to encoder 110. In an
2 embodiment, network 130 will drop low priority packets before dropping a
3 high priority packet. Network 130 may impose an additional charge for the
4 transmission of data on a high priority channel.

5 In an embodiment, network administrator 133 maintains information
6 about the amount of currently available network bandwidth and may provide
7 information about current network capacity and expected future network
8 capacity as feedback to encoder 110. For example, encoder 110 may send
9 a network capacity request 115 through network access server 131 to
10 network administrator 133, and in response network administrator 133 may
11 send network capacity information 116 through network access server 131 to
12 encoder 110. Network capacity request 115 may be a request for
13 information about the availability of capacity to send a type of data (e.g., a
14 high priority frame or base layer frame), and network capacity information
15 116 may be a response to such a request. In an embodiment, a request for
16 information sent from encoder 110 does not specify the type of data to be
17 transmitted (e.g., that the data is video-coded frames) and may be, for
18 example, a request for a specified amount of bandwidth. In this example,
19 the priority of the bandwidth, the size of the data, and/or the duration may be
20 specified. In an embodiment, a request is not required for the sending of
21 network capacity information 116, and network capacity information may be
22 sent, for example, on a periodic basis or during conditions determined by
23 network administrator 133. Of course, a person of ordinary skill in the art
24 would appreciate that network capacity request 115 and network capacity
25 information 116 may be transmitted between encoder 110 and network
26 access server 131 using the same connection as the video-coded frames
27 113. Embodiments of the present invention that make use of this network
28 capacity information when transmitting video-coded information are further
29 described below.

30 FIG. 2 is a block diagram of a video encoder according to an
31 embodiment of the present invention. FIG. 2 shows an encoder 110 such as
32 in FIG. 1 above. In addition, FIG. 2 shows a stream of video signals 112 that

1 components in encoder 110 may be embodied in software, hardware,
2 firmware, or some combination. Encoder 110 may include one or more
3 central processing units (CPUs), random access memories (RAMs), and
4 Read Only Memories (ROMs), and memories in encoder 130 may store
5 instructions to be executed by a processor to carry out embodiments of the
6 invention as described herein. The logic in encoder 110 may be embodied
7 in a special purpose processing unit such as an application specific integrated
8 circuit (ASIC). In an embodiment, encoder 110 is a personal computer (PC)
9 that contains software to carry out an embodiment of the present invention.

10 FIG. 3 is a flow diagram of a method of transmitting video information
11 according to an embodiment of the present invention. The description below
12 is explained with reference to the systems shown in FIGS. 1 and 2, but of
13 course these methods may be used with other systems. As shown in FIG. 3,
14 a frame of video data to be coded as video-coded data is received (301).
15 For example, a frame of video data may be received at encoder 110 from
16 video camera 111 or may be received from a buffer in another part of
17 encoder 110. In embodiments, the frames of video data may already be
18 stored at the encoder (e.g., buffered at the encoder) prior to coding. The
19 encoder may send a request for information relating to the network's
20 available capacity to transmit high priority data (302), and capacity
21 information may be received in response to the request (303). Examples of
22 the request and response are shown in FIG. 1 as network capacity requests
23 115 and network capacity information 116. In an embodiment, network
24 administrator 133 will determine if the capacity to send high priority data is
25 available and will send a response to encoder 110. If the response indicates
26 that the network has the capacity to transmit the frame as high priority data
27 (304), then the frame is encoded as a high priority frame (e.g., a base layer
28 frame) (305) and is transmitted as high priority data (306). If the response
29 indicates that the network does not have the capacity to transmit high priority
30 data (304), then the frame is encoded as a low priority frame (e.g., an
31 enhancement layer frame) (307) and is transmitted as low priority data (308).
32 Frames that are transmitted as high priority data may use a high priority

channel across network 130 and frames that are transmitted as low priority data may use a low priority channel across network 130.

FIG. 4 is a flow diagram of a method of transmitting video information according to another embodiment of the present invention. As in the previous embodiment, the encoder may receive a frame of video data to be coded as video-coded data (401), may send a request for information relating to the network's available capacity to transmit high priority data (402), and may receive capacity information in response to the request (403). In this embodiment, the data is video-coded (404) and the video-encoded frame is buffered (405) at substantially the same time as the request is sent and/or the response to the request is received. If the network has the capacity to transmit the frame as high priority data (406), then the request is transmitted as high priority data (407). If the network does not have the capacity to transmit high priority data (406), then the video frame is transmitted as low priority data (408). In some embodiments, such as very high compression codecs, the frame has to be recoded as a high priority frame. In other embodiments, the frame may have been coded at both priorities (high and low) in parallel, and the frame with the desired priority may be chosen at a later time.

FIG. 5 is a flow diagram of a method of transmitting video information according to another embodiment of the present invention. FIG. 5 contains steps 401 to 407 as in FIG. 4. In this embodiment, however, the encoded frame is deleted from transmission (500) if the network does not have the capacity to transmit high priority data. When an encoded frame is deleted from transmission, the video data may be lost, but such a loss may not greatly impact perceived picture quality as long as the encoder 110 is aware of the loss.

FIG. 6 is a flow diagram of a method of transmitting video information according to another embodiment of the present invention. As discussed above, a frame of video data to be coded as video-coded data may be received (601). In this embodiment, the frame is then encoded as a high priority frame (602). In this embodiment, all frames may be encoded as high

1 priority frames prior to requesting and/or receiving any information about
2 available network capacity. As shown in FIG. 5, after encoding the high
3 priority frame, a request for information relating to the network's available
4 capacity to transmitting high priority data is sent (603), and capacity
5 information is received in response to the request (604). If the network has
6 the capacity to transmit the frame as high priority data (605), then the
7 request is transmitted as high priority data (606). If the network does not
8 have the capacity to transmit high priority data (605), then the video frame is
9 transmitted as low priority data (607).

10 FIG. 7 is a flow diagram of a method of transmitting video information
11 according to another embodiment of the present invention. A frame of video
12 data to be coded as video-coded data may be received (701). In this
13 embodiment, frames are encoded as either high priority frames or low
14 priority frames based on a priority selection algorithm (702). The algorithm
15 may use information about how much bandwidth is allocated for the
16 transmission of high priority frames. The encoder then obtains information
17 relating to the network's available capacity to transmit high priority data
18 (703). This information may be obtained by network feedback or other
19 means such as the Real Time Control Protocol (RTCP) from the Internet
20 Engineering Task Force (IETF). If more than a threshold number of low
21 priority frames have been lost (704), then an additional number of the frames
22 may be encoded as high priority frames than is dictated by the transmission
23 priority algorithm discussed above. These additional high priority frames
24 may be encoded at a lower quality than is generally used for high priority
25 frames.

26 The present invention improves the transmission of video information
27 by using network feedback on available bandwidth. Through the use of
28 feedback the present invention allows for the randomization of the arrival of
29 high priority data into the network and, therefore, minimizes the likelihood of
30 network overload. The present invention may also avoid the buffering of
31 large amounts of data and the ensuing delay that such buffering may cause.
32 Several embodiments of the present invention are specifically illustrated

1 and/or described herein. However, it will be appreciated that modifications
2 and variations of the present invention are covered by the above teachings
3 and within the purview of the appended claims without departing from the
4 spirit and intended scope of the invention. For example, unless otherwise
5 specified, the order of the steps performed may be varied.

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